Measurement Apparatus

Field of the Invention

This invention relates to measurement apparatus and, in particular, to apparatus for measuring length, surface area, volume and the like of three dimensional objects.

Background to the Invention

In many different applications it is desirable to be able to accurately measure the length, surface area or volume, for example, of an object or enclosure. In particular, for example, it is often desirable to be able to estimate the quantity of paint or wallpaper one might require to decorate a room, or the number of tiles which may be required to cover a roof. However, it is often impractical, difficult or simply impossible to measure the required dimension by hand using a tape measure or the like.

US Patent No. 4,730,190 describes a hand-held measuring device which operates effectively as a remote tape measure. Thus, the user measures the three dimensions of, for example, a room and the device multiplies the three dimensions to give the volume of the room.

However, this type of device is time-consuming to use and prone to error. Further, it is really only suitable for giving accurate volume measurements of substantially uniform right-angled areas. It would not give an accurate measurement for an area having curved or irregular sides, for example, and straight line approximations are not accurate enough for many

applications. Further, the area to be measured must be accessible to the user in order for the relevant lengths to be measured. Thus, for example, it would be difficult for a user to measure the volume or surface area of a roof without having to climb up on the roof to take the relevant measurements.

We have now devised an arrangement which overcomes the problems outlined above.

Summary of the Invention

In accordance with the present invention, there is provided a measurement apparatus for measuring at least one parameter of an object or area, the measurement apparatus comprising one or more imaging and display devices for creating a three-dimensional map and displaying an image of said object or area, mapping apparatus for mapping a virtual shape onto said image and substantially matching said shape to said object or area, the measurement apparatus being adapted to determine from said image at least one parameter of said object or area, said parameter comprising at least one of a length, surface area or volume of said object or area.

It will be appreciated that the shape matching takes place in a two-dimensional image space, and the apparatus can create any (selected or otherwise) two-dimensional perspective from the three-dimensional map, thereby permitting a user to choose the perspective in which matching takes place, which may be particularly important in the case where important matching points cannot be seen from a particular perspective.

The present invention also extends to a method of measuring an object or area, the method comprising the steps of creating a three-dimensional map and displaying an image of an object or area to be measured, mapping a virtual shape onto said image, substantially matching said virtual shape to said object or area being measured, and determining at least one of a length, surface area or volume of said object or area.

The apparatus preferably includes means for marking or otherwise selecting the object or area to be measured within an image, by defining an outline of the shape of said object or area. The apparatus then preferably creates a virtual shape which substantially matches the outline. The apparatus beneficially includes means for permitting the user to alter one or more of the size, angle or pitch of the virtual shape.

Thus, the present invention employs an imaging technique which can recover depth as well as azimuth and elevation. The apparatus of the present invention is particularly (but not exclusively) useful for quickly and accurately estimating quantities of, for example, paint, wallpaper, tiles or carpet required for a particular area. In fact, the apparatus may include means for providing an estimate of the amount of such materials which are required. It may also include means for taking into account standard material widths, lengths, volumes, etc, when estimating the quantities of a material required to be obtained.

Brief Description of the Drawings

An exemplary embodiment of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram to illustrate the "correspondence" and triangulation techniques used in some prior art imaging devices to construct a three-dimensional map of an object, area or environment;

Figure 2 is a schematic representation of an exemplary embodiment of the present invention in which a user has marked or drawn around an object or area of interest;

Figure 3 is the apparatus of Figure 2 in which a virtual shape has been created and demonstrating that the user can alter the shape with a plurality of degrees of freedom to substantially match it to the object or area of interest; and

Figure 4 is the apparatus of Figure 3 in which the surface area of the object or area of interest is calculated and displayed.

Detailed Description of the Invention

There are various imaging devices in accordance with the prior art which can construct a three dimensional map of an object, area or environment of interest. Generally, in these devices, two or more imaging devices, such as cameras, are separated in space and arranged to capture a respective image of the object, area or environment of interest.

Referring now to Figure 1 of the drawings, two imaging devices 10, 12 are arranged in spaced apart relation relative to an object 14 of interest. The degree of separation d of the imaging devices 10, 12 is known or can be measured.

Correspondence between the image points for each point on the object 14 as captured by the imaging devices 10, 12 is established by a pattern matching algorithm. For example, Stereo (two image) adaptive least square matching as described in Chapter 8 of Close Range Photogrammetry and Machine Vision edited by K.B. Atkinson (Whittles Publishing 1996). The position of an image point in the image plane of a camera along with knowledge of its focal length directly gives the azimuth and elevation angle of the object point relative to that camera.

The depth of the point on object 14 can now be established by "triangulation" in which an imaginary triangle is drawn between the point on object 14 and the corresponding points on the images (as shown in Figure 1). In the simplest case when the elevation angle is zero, the imaginary triangle has baseline length d and the two angles at the base of the triangle are the azimuth angles of the object point as seen from each camera. The distance of the object from the baseline can now be calculated using standard trigonometrical formulae. See Three Dimensional Computer Vision by Olivier Faugeras (MIT Press 1993) for a full mathematical treatment.

The result is an image of the object 14 made up of a plurality of pixels, each of the pixels containing (or having associated therewith) a depth value (i.e. information relating to the depth) for all points on the object 14. In other words, an image of the object 14 in which the three-dimensional position of each pixel is known.

Referring now to Figure 2 of the drawings, in the apparatus according to an exemplary embodiment of the present invention, such a three dimensionally mapped image of an environment of interest is created and displayed on a screen 16. The user can mark the area 22 of the image which is required to be measured, using, for example, any known video display pen marking methods on a touch-sensitive screen 16, by drawing roughly around the apparent edges of the area 22.

The apparatus further comprises a menu 18 (also displayed on the screen 16) giving a user the option to select one of a number of predefined measurements, such as length, surface area, volume, etc. The user selects a desired measurement for the marked area 22.

The apparatus then creates a virtual shape 20 to match the selected area 22 and overlays it on the image. The user can alter the size, pitch angle, etc. of the virtual shape 20 as required to match it as closely as possible to the area of interest (see Figure 3). It is envisaged to provide up to six degrees of freedom to the user for alteration of the virtual shape 20 to match it to the area 22 of interest.

Once the virtual shape 20 is as closely matched as possible, the user selects the calculate option. Because the θ, φ and r values of all coordinates of the area 22 are known, the same values of all coordinates of the virtual shape 20 are also known. Further, the focal length of the imaging devices 10, 12 are known (or can be determined), so measurements such as surface area, volume, etc. of the area 22 of interest can be accurately calculated (see Figure 4).

Thus, estimates of length, surface area, volume, etc. can be quickly and efficiently obtained.

It is envisaged that, in an alternative embodiment of the invention, the apparatus may be arranged to automatically match the virtual three-dimensional shape onto the area of interest. Further, it is envisaged that the apparatus may also provide a plurality of predefined virtual shapes for selection by the user, which can then be dragged into the image space.

An algorithm for fitting standard material widths to irregular areas could also be employed.

An embodiment of the present invention has been described above by way of example only, and it will be apparent to a person skilled in the art that modifications and variations can be made without departing from the scope of the invention as defined in the appended claims.